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ABSTRACT

Summary descriptions of selected urban simulations and games that have been developed outside the Institute For The Future are presented. The operating characteristics and potential applications of each model are described. These include (1) the history of development, (2) model and player requirements, (3) a description of the environment being simulated, and (4) computer specifications and requirements. A genealogy and chronology of all major urban simulation efforts to date is also provided. (DGC)

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SELECTED URBAN SIMULATIONS AND GAMES

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FOREWORD

The development of an urban research laboratory is a major project at IFF. An integral part of this effort, currently sponsored by Wesleyan University, is devoted to the construction and operation of urban simulations. The intent of the work is to improve simulation techniques and to provide a variety of new urban models for use as educational devices in the classroom or as research tools.

This paper describes features of selected urban simulations and games that have been developed elsewhere, and provides a genealogy and chronology of all major urban simulation efforts to date.

A companion volume provides a bibliography of the published materials of greatest value in designing the first urban simulation model at IFF.*

* Mark Nagelberg, *Simulation of Urban Systems: A Selected Bibliography*, IFF Working Paper WP-3, January 1970.

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INTRODUCTION

This paper outlines a number of simulation projects that have been described in published reports. Many of the models described here have never been made fully operational, and those that are still being used are under constant modification. Each "model" is, then actually a series of models, games, or computer programs embodied in some over-all simulation effort. As a result, full documentation of these projects is quite difficult, particularly where computerization is involved. In many instances, good guesses and word of mouth are the best sources.

The models are of three basic types:

1. *Computer simulations*, which use the large manipulative and tabulational capabilities of modern computers to explore complex mathematical models of urban processes and structures.
2. *Games*, which attempt to simulate the experiences and psychologies of thousands or millions of decisionmakers by condensing their roles into a few archetypal forms or player-positions, and by applying rules that reflect the restrictions of real life.
3. *Gaming simulations*, which use computer simulation to provide both a convincing environment for the game and a kind of laboratory for urban experimentation. Games may be computer-assisted without being gaming simulations (if, for example, the computer merely keeps score); on the other hand, computer simulations sometimes employ the decision-theory and role-theory of games, and can potentially assume some of the responsibilities of human players.

Information on each of the models included in this paper is organized into the following categories, presented here in the order in which they appear:

- a. *Purpose* describes the kind of final output sought in the simulation.

- b. *Principal developer* identifies the one or two key figures involved in the project.
- c. *Uses* refers to the activities or roles in which the simulation is employed.
- d. *When in development and use* refers to the date of first operation; in most cases this can only be approximated.
- e. *Costs* provides incomplete data; the duration (in time) of computer iterations is occasionally provided as some indication of expense.
- f. *Where developed* attempts to identify the center where the research was undertaken.
- g. *Prototypes* includes earlier efforts if they served as structural or theoretical paradigms, if they inspired development of the model, or if they provided important inputs of data, experiences, ideas or personnel.
- h. *Types of assumptions* indicates the model builder's choice between a technique of theoretical explanation, a description of phenomena, or a combination of both.
- i. *Number of players* pertains only to games and gaming simulation.
- j. *Related and later developments* provides information on a basis similar to that for *Prototypes*.
- k. *Surrogate of what city*: the typical model, especially if it adopts a descriptive strategy, is designed or applied as a surrogate; the subject city is indicated in this category.
- l. *Type of model* identifies the project as a computer simulation, a game, or a gaming simulation.
- m. *Computer, language, and program* is provided for only some of the models, as information about computerization and computer requirements is scanty.
- n. *Number and types of parameters* refers primarily to models involving computers. The information presented is often incomplete because the total number of unknowns generated in the computer is seldom specified. In the case of games, this category is used to indicate complexity and information requirements.

- o. *Storage requirements* refers to models using computers. Data on these requirements are largely unavailable.
- p. *Data input requirements* describes the inputs that must be provided by the experimenter. When the number of data input items is unknown, this category is used to describe the types of data needed, and sometimes remarks on the ease or difficulty of obtaining data.
- q. *Documentary sources* lists major publications on the simulation. Frequently, only a small part of the total published documentation is cited, but an attempt is made to furnish the more important or more easily available titles.
- r. *Features* includes data on the scope, concerns, and especially the processes of the model.

A genealogy and chronology of the outlined simulations, some of their prototypes, and some newly-created manual games appear at the end of the volume.

MODEL APEX (Air Pollution Exercise)	
a. Purpose	Allow people to experience, in a shorter time span, the nature of complex urban processes with emphasis on political conflict, operations of long range planning, given the necessity for short run decisionmaking, and the relationship of air pollution control to natural urban development.
b. Principal developer	Richard D. Duke; also, Stewart Marquis, Roy I. Miller and Donald S. Kiel.
c. Uses	1. Training for people with interests ranging from air pollution through land use planning to political science. 2. Professional experiment in a simulated but representative environmental experiment.
e. Costs	Described as "moderate," high labor inputs.
d. When in development and use	Developed in 1969. In use at present.
f. Where developed	University of Michigan and University of Southern California.
g. Prototypes	M.E.T.R.O. and METROPOLIS.
h. Types of assumptions	Theoretically-based models linked with data descriptive of the urban area.
i. Number of players	18 to 75.
j. Related and later developments	Continuing development.
k. Surrogate of what city	Lansing, Michigan. Features to generalize the Lansing area are included. Area ranges in size from 250,000 to 500,000 people.
l. Type of model	Game-type "active" machine simulation. Included are a market model of urban growth a simulation of electro-process and a stochastic simulation of air quality.
m. Computer, language and program	IBM 1130, Fortran IV.
n. Number and types of parameters	Not known.
o. Storage requirements	2 IBM 1130 disc cartridges.
p. Data input requirements	Demographic, land use, land value on a census tract basis. Seasonal weather analysis and emission rates for contaminants from various sources. Municipal fiscal data. Voting patterns through time.
q. Documentary sources	Anne Cochran, Introduction to APEX (to be published).
r. Features	Five player roles: 1) politician, 2) planners, 3) land developers, 4) industrialists, 5) air pollution control officers. Roles interact, through joint development of a metropolitan area, by making inputs to a series of linked models, including an urban spatial location model, an air quality model, a voter response model, and a candidate election model. Public opinion is brought to bear through a newspaper printed each cycle. Issues in the newspaper reflect the decisions made by the players. The budgetary process is central to the decisionmaking in most roles. Several cycles of decisions, each representing one year, are played with each generalizing a new set of computer output.

MODEL CATS (CHICAGO AREA TRANSPORTATION STUDY)	
a. Purpose	Allocation of land uses to land sites relative to transportation accessibility.
b. Principal developer	John. R. Hamburg. Later development: George Lathrop and Hamburg. Also: Morton Schneider.
c. Uses	1. Planning future transportation. 2. Projection of gross aspects of urban growth and sprawl.
d. When in development and use	Original study, 1958-1960. Continuing development to at least 1965. Not known if presently used.
e. Costs	Not known.
f. Where developed	Chicago
g. Prototypes	Morton Schneider's intervening opportunity model.
h. Types of assumptions	Descriptive, statistical.
i. Number of players	None.
j. Related and later developments	PATS (Pittsburgh Area Transportation Study), DATS (Detroit Area Transportation Study), and N. Y. Dept. of Public Works. Most other transportation models refer to CATS.
k. Surrogate of what city	Chicago; later: Niagara Falls, N.Y.
l. Type of model	Computer simulation (probabilistic allocation of activities to land parcels).
m. Computer, language and program	Not known.
n. Number and types of parameters	For each "traffic zone": six operations of allocation and no more than five major independent variables. Probability parameters calculated through an independent model of transportation accessibility with three to six independent variables.
o. Storage requirements	Not known.
p. Data input requirements	For total region: projections of population and growth in following activities: 1) open space and transportation, 2) commercial, 3) residential, 4) industrial. For each "traffic zone": tabulation of current land uses, and projection of probable zoning. Number of data input items not known.
q. Documentary sources	Chicago Area Transportation Study, Final Report, Vol. II: "Data Projections" (1960). George Lathrop, John Hamburg & Frederick Young, "Opportunity - Accessibility Model for Allocating Regional Growth," Highway Research Record, No. 102 (1965), pp. 54-66. Also: George Lathrop and John Hamburg, article of same title in The Journal of American Institute of Planners, Vol. 31, No. 2 (1965), pp. 95-103.
r. Features	Population and economic forecasts, redevelopment plans, and zoning plans all determined exogenously. Based on current land use data; "unusable land" is removed from each "traffic analysis zone" (a geometric parcel). Required total for each activity (determined by plans and forecasts), allocated to available land parcels according to a probability factor proportional to accessibility and "holding capacity." Resultant mix of land uses for each traffic zone then becomes an input for transportation forecast. In N.Y. Public Works version, transportation is de-emphasized, and controls of density and open space are added. All allocations are consistent with zoning regulations.

MODEL CITY I	
a. Purpose To simulate governmental decision-making and its interaction with a socio-economic system represented simultaneously. To represent intra-metropolitan cooperation and competition.	
b. Principal developer Peter House.	c. Uses 1. Heuristic gaming. 2. Professional education.
d. When in development and use 1968 - 1969	e. Costs Completion costs: \$100,000. Operating costs not known.
f. Where developed Washington Center for Metropolitan Studies, Washington, D.C.	g. Prototypes Region, CLUG.
h. Types of assumptions Theoretical.	i. Number of players 27 - 45 (in nine teams).
j. Related and later developments Evolved into City II and then into the City Model.	
k. Surrogate of what city "City I" is hypothetical.	
l. Type of model Computer-assisted game with both "systemic" and "role-playing" aspects. Computer used for tabulation and for expediting game by optimizing economic relationships.	
m. Computer, language and program IBM 1130, FORTRAN IV, no knowledge of listing.	
n. Number and types of parameters With new maximizing and tabulating functions, much greater than for Region II. No other knowledge.	
o. Storage requirements Not known.	
p. Data input requirements Generated in game.	r. Features Divided into systemic economic sector and role-playing governmental sector. In latter, nine teams assigned nine different roles: chairman, councilman, heads of five municipal departments, citizens, and mass media. Play centers around role-cooperation in government, and inter-group cooperation in land development. Four different governmental jurisdictions in a single metropolitan area. Otherwise very similar to Region II.
q. Documentary sources Washington Center for Metropolitan Studies, City I Player's Manual (Washington, Oct. 1968). "Urban Planners Play A Game Called City I," Business Week, Nov. 16, 1963, pp. 56-70.	

MODEL	CITY II	
a. Purpose	To simulate governmental decision making and its interaction, with a socio-economic system represented simultaneously. To represent intra-metropolitan cooperation and competition.	
b. Principal developer	Peter House.	
c. Uses	1. Heuristic gaming. 2. Professional education.	
d. When in development and use	Initial run June, 1969.	
e. Costs	Not known. Developed in part under contract for the Department of Transportation and Washington Center for Metropolitan Studies.	
f. Where developed	Envirometrics, 1100-17th St. N.W., Washington, D. C.	
g. Prototypes	Region, CLUG, and City I.	
h. Types of assumptions	Theoretical.	
i. Number of players	Not fixed. Five to 30 teams with one to five members per team. 30 to 125 players.	
j. Related and later developments	Metropolitan Model in design stage. Modular design will add variable population characteristics, joint public and private land use, and more public institutions.	
k. Surrogate of what city	City II is hypothetical. The load program allows the user to input cities of different sizes, ranging from 400,000 to 2,000,000 population. A more simplified teletype version of the model is also available.	
l. Type of model	Computer-assisted game with both "systemic" and "role-playing" aspects. Computer used for optimizing economic relationships, level and nature of migration, and for simulation of the granting of Federal-state aid.	
m. Computer, language and program	UNIVAC - 1108 or GE 635, Fortran IV.	
n. Number and types of parameters		
o. Storage requirements	Not known.	
p. Data input requirements	Generated in game.	x. Features Five to thirty teams with one to five members per team acting as entrepreneurs and owning economic developments in a simulated metropolitan area. The population size, geographical configuration, and political jurisdiction boundaries are chosen before play from a variety of metropolitan choices. Each team is elected or appointed by elected officials to assume the duties of one of the governmental roles which are played simultaneously with the entrepreneurial functions. The chief elected official in each jurisdiction appoints other teams to play the roles of the School, Municipal Services, Highway, Planning and Zoning. Players also make social decisions--time allocation, boycotting decisions, and voting decisions--for the classes of residents in the community.
q. Documentary sources	Environmetrics, City Manual, [Washington, November 1969]. Peter House and Philip D. Patterson, Jr., "An Environmental Gaming Simulation Laboratory," American Institute of Planners, Journal, Vol. XXV, No. 6 [Nov. 1969].	

MODEL C.L.U.G. (CORNELL LAND USE GAME) (COMMUNITY LAND USE GAME)	
a. Purpose	To represent the allocation of uses to sites given problems of accessibility, taxation, deterioration, and capital availability.
b. Principal developer	Allan Feldt.
c. Uses	Professional Education.
d. When in development and use	In use since 1963.
e. Costs	One to two man years, \$20,000-\$30,000.
f. Where developed	Cornell University
g. Prototypes	None.
h. Types of assumptions	Theoretical.
i. Number of players	5 teams, 1 - 3 players each.
j. Related and later developments	1) Original non-empirical game applied to the case of Syracuse, N.Y.; 2) Advanced modified versions developed by G. Huggar and E. Foster at the Institute for Public and International Affairs, University of Pittsburgh; 3) "action" and "City Model"; 4) Eleven county central New York game in development.
k. Surrogate of what city	In early development: none (a general game which "generates" the city of 100,000 in its operation). In later development: Syracuse, N.Y.
l. Type of model	Complex non-role-differentiated "systemic" game. May be computer-assisted for bookkeeping.
m. Computer, language and program	FORTAN IV, IBM 1130 if required.
n. Number and types of parameters	Not known. But 15-20 major variables for all operations. Increased parameters for more complex versions.
o. Storage requirements	Not known.
p. Data input requirements	None for early version.
q. Documentary sources	Allan G. Feldt, "The Cornell Land Use Game," Misc. Papers No. 3, Center for Housing and Environmental Studies, Division of Urban Studies, Cornell Univ., New York. Model discussed in: Allan G. Feldt, "Operational Gaming in Planning Education," American Institute of Planners, Journal, Vol. 32, No. 1 (Jan. 1966), pp. 17-23.
r. Features	(Basic Game) Three individual players or three teams. Cycle requires half hour. City of a quarter million generated from zero in 20 cycles. Predetermined conditions for each round: location and efficiency of highway network, location of points of access to external transportation (nodes or ports), level and type of taxation, types of land uses. Player begins with fixed amount of capital for a purchase of land, b) construction, c) hiring industrial employees, or d) gaining commercial customers by improving access. Principal element in land decisions: accessibility of sites to uses. Money enters system through payments to industry from exogenous sources. Leaves system through transit costs, taxes, and building depreciation. Players seek to 1) improve accessibilities, 2) manage community capital improvements, and 3) maintain buildings (which otherwise deteriorate). Faldt describes game as a complex "div. between monopoly and chess."

MODEL EMPIRIC (TRAFFIC RESEARCH CORPORATION)	
a. Purpose	To project allocation of population and employment to political non-geometric districts (no allocation of particular activities to particular sites).
b. Principal developer	Donald M. Hill.
c. Uses	1. General forecasts for transportation planning.
d. When in development and use	Early to mid 60's.
e. Costs	Not known.
f. Where developed	Boston, Traffic Research Corporation.
g. Prototypes	POLIMETRIC.
h. Types of assumptions	Descriptive, statistical.
i. Number of players	None.
j. Related and later developments	None.
k. Surrogate of what city	Boston and eastern Massachusetts.
l. Type of model	Linear programming computer simulation.
m. Computer, language and program	None.
n. Number and types of parameters	Not known, but not over 30 major variables.
o. Storage requirements	Not known.
p. Data input requirements	Exogenous population and business development projections. Planned "locator" improvements for each zone. Coefficients determined through factor analysis. No knowledge of number of data input items.
q. Documentary sources	Donald M. Hill, "A Growth Allocation Model for the Boston Region," American Institute of Planners, Journal, Vol. 31, No. 2 (May 1965), pp. 111-120; Donald M. Hill, Daniel Brand, and Willard B. Hansen, "Prototype Development of a Statistical Land Use Prediction Model for the Greater Boston Region," Highway Research Board Record, No. 114 (1965), pp. 51-70.
r. Features	Five "located" variables (types of population and employment) are allocated to 29 politically-defined subregions, in a continuous relation to 14-22 "locator" variables. Locator variables correspond to varieties of social and private overhead capital. In ten-year projections, percent changes (rather than absolute quantities) in the varieties of population and employment are distributed. Period 1960-60 was projected. Also, 40-year recursive projections for year 2000 were made. Multiple regression equations for each of the locator variables were developed.

MODEL HERBERT-STEVENS MODEL. ALSO KNOWN AS PENN-PLANEY TRANSPORTATION MODEL (ABANDONED BY P-J BEFORE COMPLETION).			
a. Purpose	Representation of residential location and transportation demand through simulation of the microstructure of market demand for land.		
b. Principal developer	Benjamin Stevens and Britton Harris (Institute of Urban Studies, University of Pennsylvania).	c. Uses	1. Modeling research. 2. Planning (if sufficient data can be obtained).
d. When in development and use	In some form, 1960 to at least 1967. Not known if presently used.	e. Costs	Not known.
f. Where developed	Philadelphia (University of Pennsylvania)	g. Prototypes	None.
h. Types of assumptions	Theoretical, atemporal.	i. Number of players	None.
j. Related and later developments	Modifications by Harris.		
k. Surrogate of what city	Philadelphia and the Delaware Valley.		
l. Type of model	Computer simulation using linear programming.		
m. Computer, language and program	Not known.		
n. Number and types of parameters	Not known.		
o. Storage requirements	Not known.		
p. Data input requirements	Not known, but very large. Detailed demographic, real estate and transit cost information. In early development, one-to-one data collection was attempted.		
q. Documentary sources	John D. Herbert and Benjamin H. Stevens, "A Model for the Distribution of Residential Activity in Urban Areas," Journal of Regional Science, Vol. 2, No. 2 (1960), 21-37; Benjamin H. Stevens, "Linear Programming and Location Rent," Journal of Regional Science, Vol. 3, No. 2 (1961). Also two documents by Britton Harris, et al. (1966) (noted but not seen).		
r. Features	Originally planned as one of a set of models for the P-J study. In use, it described residential activity and location and de-emphasized transportation aspect. Available land for household location, and the number of households to locate per iteration are determined exogenously. All sites (districts) are disaggregated according to size of lot, type and quality of structure, and accessibility to trip destination alternatives by type of household. Households are similarly disaggregated according to income, patterns of consumption, and patterns of daily movement. Each "variety" of household is matched to each variety of site-district, such that "rent-paying-ability"---the difference between the available household budget for housing and transportation, and the free market cost if sites were free---is maximized. In the later versions, total rent-paying ability, rather than location rent-paying ability is maximized.		

MODEL LOWRY MODEL, also known as PITTSBURGH MODEL (to be distinguished from the "Pittsburgh Urban Simulation Model").	
a. Purpose	To represent a total urban system in large generalized aggregates.
b. Principal developer	Ira Lowry.
c. Uses	1. Modeling research. 2. A practical planning tool.
d. When in development and use	1963 - 1966.
e. Costs	The complete iteration of the model takes 17 minutes on the IBM 7090. Nothing else known.
f. Where developed	Pittsburgh, Santa Monica.
g. Prototypes	To a limited degree, PATS.
h. Types of assumptions	Theoretical (tied to planning theory and not to initial data). atemporal.
i. Number of players	None.
j. Related and later developments	TOMM, The Pittsburgh Urban Simulation.
k. Surrogate of what city	Pittsburgh.
l. Type of model	Computer simulation with two distinct allocation subroutines (the retail "loop," and the residential "loop") near-equilibrium by three successive iterative sequences.
m. Computer, language and program	IBM 7090 with 1401 hardware, no knowledge of language, program written by John F. Muth (Carnegie Tech) and Gary Brown (Rand).
n. Number and types of parameters	Not known.
o. Storage requirements	Not known.
p. Data input requirements	Not known, but include: retail employer per household, size of establishment, accessibility coefficients, population and employment for all sectors and types, land use constraints and public improvements, location of basic employment.
q. Documentary sources	Ira S. Lowry, A Model of Metropolis (RAND RM-4035-RC, Santa Monica, August 1964).
r. Features	"Basic" employment (engaged in enterprise serving customers outside the city) determined exogenously. Total employment projected from basic employment. Households located according to accessibility to employment and retail services. Retail employers are disaggregated into neighborhood, local, or metropolitan retailers, and are located in relation to basic households. Non-basic households are then located. Except for division into three density levels, all households are homogeneous. Model begins with a "blank map" of mile-square tracts and "creates" the city in a single equilibrium solution. It is "temporal" and cannot model "lags."

MODEL	M.E.T.R.O.	
a. Purpose	Exacting simulation of complex metropolitan processes including spatial location, voter response, candidate election, municipal budgeting, residential housing market, and school administration.	
b. Principal developer	Richard D. Duke; also, Paul Ray, Tom Bort, Don Kiel, and Roy Miller	
c. Uses	1. Operational gaming for actual decisionmaking in local government. 2. Professional education.	
d. When in development and use	In development, 1966-1968. In use at present.	
e. Costs	Described as "moderate," high labor inputs. Partially developed with funds from the Department of Housing and Urban Development and the Ford Foundation.	
f. Where developed	MSU; University of Michigan.	
g. Prototypes	METROPOLIS (1963-present).	
h. Types of assumptions	Descriptive in most machine aspects. Theoretical in gaming aspects.	
i. Number of players	Up to 60, usually 25, not less than 15.	
j. Related and later developments	APEX (Air Pollution Exercise).	
k. Surrogate of what city	Lansing, Michigan. Claims greater generality. Size of metro area assumed: 250,000-500,000 population.	
l. Type of model	Game-type "active" machine simulation. Stochastic simulation of electoral polity. Simulation of economic and social structure.	
m. Computer, language and program	IBM-1130, Basic Fortran IV.	
n. Number and types of parameters	Not known.	
o. Storage requirements	2 - IBM-1130 Disk Cartridges.	
p. Data input requirements	To achieve all M.E.T.R.O. goals, large quantities of data are required including demographic, land use, land value, voting patterns, municipal fiscal and educational sector data. Duke describes the requirements as "moderate" as compared with an equivalent "pure" computer simulation.	
q. Documentary sources	A three-page description in John P. Crecine, Computer Simulation in Urban Research (Santa Monica: The RAND Corp., Nov. 1967) pp. 24 ff. Discussion in Richard Meier and R. Duke, "Gaming Simulation for Urban Planning," American Institute of Planners, Journal, Vol. 32, No. 1 (Jan. 1966), pp. 3-17. Paul H. Ray and Richard D. Duke "The Environment of Decision Makers in Urban Gaming Simulations," in Simulation in the Study of Politics, William Coplin (ed.) (Chicago: Markham Press, 1968.)	
r. Features	Four player roles: 1) politician, 2) planner, 3) land developer, 4) educator. Four machine submodels: 1) "voters," 2) urban budget, 3) socio-economic characteristics, 4) "households and firms." Heart of simulation is interaction between urban budget submodel, which is strongly influenced by the ongoing game, and the socio-economic characteristics submodel. Stresses competition for funds between school board and municipal government. Attempt at sophistication and realism.	

MODEL		METROPOLIS	
a. Purpose Simulation of typical public capital investment process.			
b. Principal developer		Richard D. Duke	
c. Uses		1. Professional training. 2. Continuing education of planners.	
d. When in development and use		1963,- present	
e. Costs		Unavailable (but relatively low).	
f. Where developed		Michigan State University and University of Michigan.	
g. Prototypes		None.	
h. Types of assumptions		Descriptive.	
i. Number of players		Three to 21 per game plus operator. As many as five games can be run simultaneously.	
j. Related and later developments		APEX; M.E.T.R.O. Gaming - Simulation, Richard Duke, now functioning; updated Metropolis game, with distinct "planner" and "school board" rules.	
k. Surrogate of what city		Lansing.	
l. Type of model Non-computer-assisted game, current versions also computerized.			
m. Computer, language and program		Basic Fortran IV.	
n. Number and types of parameters		Not known.	
o. Storage requirements Where applicable, not known.			
p. Data input requirements		Age - sex distribution, general population characteristics, labor force characteristics, occupancy and structural characteristics of housing units, city budget expenditures and itemized revenue, assessed value of real estate and tax rate, list of city capital projects under way, brief history of "Metropolis."	
q. Documentary sources		Richard D. Duke, Gaming - Simulation in Urban Research, (East Lansing: Institute for Community Development and Services, Continuing Education Service, Michigan State University, 1964). Excerpted from "Gaming - Simulation Studies in Urban Land Use Allocation," Ph.D. Dissertation, Univ. of Michigan, Ann Arbor, 1964.	
r. Features		Role-playing; three teams: 1) politicians (city council), 2) administrators (city executive including a "planner"), and 3) speculators (land developers). "Illusion of reality" introduced through mock newspapers, mock public opinion polls, and manipulated statistical information concerning Lansing, Michigan. "Status" of each player objectively defined as a stock of "utils." Played in cycles representing investment decision periods; following every three cycles, elections are held.	

MODEL PATS (PITTSBURGH AREA TRANSPORTATION STUDY)	
a. Purpose	Allocation of land uses to land sites in relation to transportation accessibility.
b. Principal developer	John Hamburg, George Haikalis, Morton Schneider.
c. Uses	1. Planning future transportation. 2. Projection of gross aspects of urban growth and sprawl.
d. When in development and use	1959 - 1963.
e. Costs	Not known.
f. Where developed	Pittsburgh.
g. Prototypes	CATS
h. Types of assumptions	Descriptive, statistical.
i. Number of players	None.
j. Related and later developments	Not known.
k. Surrogate of what city	Pittsburgh.
l. Type of model	Computer simulation (probabilistic allocation of activities to land parcels).
m. Computer, language and program	Not known.
n. Number and types of parameters	For each "traffic zone": six operations of allocation and no more than five major independent variables. Probability parameters calculated through an independent model of transportation accessibility with three to six independent variables.
o. Storage requirements	Not known.
p. Data input requirements	For total region: projections of population and growth in following activities: 1) open space and transportation, 2) commercial, 3) residential, 4) industrial. For each "traffic zone": tabulation of current land uses, and projection of probable zoning. Number of data input items not known.
q. Documentary sources	Pittsburgh Area Transportation Study, Final Report, Vol. II: "Forecasts and Plans" (Feb. 1963).
r. Features	Population and economic forecasts, redevelopment plans, and zoning plans all determined exogenously. Based on current land use data; "unusable land" is removed from each "traffic analysis zone" (a geometric parcel). Required total for each activity (determined by plans and forecasts), allocated to available land parcels according to a probability factor proportional to accessibility and "holding capacity." Resultant mix of land uses for each traffic zone then becomes an input for transportation forecast.

MODEL THE PITTSBURGH URBAN, SIMULATION INCLUDING TOMM (TIME-ORIENTED METROPOLITAN MODEL)			
a. Purpose	The first calibrated "total" urban simulation.		
b. Principal developer	The total simulation: Wilbur Steger and the COMSAD Corporation; TOMM: John P. Crecine and RAND.		
c. Uses	1. Planning.	2. Model research.	3. Advanced planning education.
d. When in development and use	1964.	Not known if presently used.	
e. Costs	Not known.		
f. Where developed	Pittsburgh, Santa Monica, Lansing, Michigan.		
g. Prototypes	The Lowry Model (A Model of Metropolis).		
h. Types of assumptions	Largely theoretical, but descriptive in representation of several accessory subroutines.		
i. Number of players	None.		
j. Related and later developments	TOMM incorporated into METRO. (TOMM also modified into a "dynamic" program).		
k. Surrogate of what city	Pittsburgh, Lansing.		
l. Type of model	Complex multistage machine simulation with at least 39 computer subroutines and with some subroutines (e.g., TOMM) having as many sub-subroutines. Component factor and multiple regression procedures used to reduce the data. Institutionalization of a data-collecting organization.		
m. Computer, language and program	Not known, program for TOMM described in Crecine, A Dynamic Model... (See q. below.)		
n. Number and types of parameters	Probably over 200 major variables in total simulation with perhaps hundreds of thousands of unknowns. (For most advanced versions).		
o. Storage requirements	Not known.		
p. Data input requirements	Immense. Unmanageable without large-scale, full-time data collection. Number of data items not known. q. Documentary sources John P. Crecine, Time Oriented Metropolitan Model, CRP Technical Bulletin No. 5, Pittsburgh City Planning Department, Jan. 1964; Wilbur A. Steger, "Analytic Techniques to Determine the Needs and Forces for Urban Renewal Action," in Proceedings IMW Scientific Computing Symposium, Simulation Models and Gaming (IBM, White Plains, N.Y., 1966), 1964; Wilbur A. Steger, "The Pittsburgh Urban Renewal Simulation," American Institute of Planners, Journal, Vol. 31, No. 2 (May, 1965), pp. 144-149; John P. Crecine, A Dynamic Model of Urban Structure (RAND P-1803, Santa Monica, Cal. (March 1968)). r. Features The Total Simulation: Basic employment model (BASEMP) and input/output survey (IODAT) are inputs to input/output Inter-Industry Model (IOIIM). An Exogenous Population Model (EXOPOP) is disaggregated for the particular		

MODEL P.O.G.E. (PLANNING OPERATIONAL GAMING EXPERIMENT)			
a. Purpose		To represent process of change in zoning regulations.	
b. Principal developer	Francis H. Hendricks	c. Uses	Not known.
d. When in development and use	Used occasionally at Cornell 1962-1964.	e. Costs	Not known.
f. Where developed	U.S. Navy.	g. Prototypes	Not known.
h. Types of assumptions		i. Number of players	Two.
j. Related and later developments	None.		
k. Surrogate of what city	None.		
l. Type of model	Non-computer, non-zero-sum game.		
m. Computer, language and program	None.		
n. Number and types of parameters			
o. Storage requirements			
p. Data input requirements			
q. Documentary sources	Francis H. Hendricks, "Planning Operational Gaming Experiment," paper prepared for the Northwestern California Chapter, Amer. Inst. of Planners, Professional Meeting on "New Ideas in Planning," Nov. 19, 1960. (noted but not seen)		
r. Features	Game dealing with interactions of planners and real estate speculators. (Two roles) Players choose competing strategies to determine outcome of requests for variances. Decision determined through probabilities given in game payoff matrices.		

POLIMETRIC (TRAFFIC RESEARCH CORPORATION & DELAWARE VALLEY REGIONAL PLANNING COMMISSION)			
a. Purpose	To represent changes in residential population and employment as a function of migration and area-wide growth for a set of non-geometric districts.		
b. Principal developer	Richard Bolan and David Seidman.		
c. Uses	Projection of demand for transportation-transit planning.		
d. When in development and use	Early 60's.		
e. Costs	Not known.		
f. Where developed in Philadelphia.	Developed in Boston, but principally used in Philadelphia.		
g. Prototypes	None.		
h. Types of assumptions	Descriptive, statistical.		
i. Number of players	None.		
j. Related and later developments	EMPIRIC, RESLOC, LINTA.		
k. Surrogate of what city because of "difficult" data requirements.	Boston, Philadelphia. Abandoned in Boston in favor of EMPIRIC. Never fully developed in Philadelphia.		
l. Type of model	Computer simulation which solves two non-linear equations for each district (one for each activity type).		
m. Computer, language and program	Not known.		
n. Number and types of parameters	Not known.		
o. Storage requirements	Not known.		
p. Data input requirements	Not complete, but include: desirability of each activity, measured by intensity and accessibility; mobility coefficients; growth coefficients; population and employment data for each district. Considered difficult to fulfill in Philadelphia.		
q. Documentary sources	For Boston: Richard S. Bolan, Willard B. Hansen, Neal A. Irwin, and Karl H. Dieter, "Planning Applications of a Simulation Model," paper prepared for New England Section, Regional Science Association, Fall Meeting (Boston College, Oct. 1963). For Philadelphia: David R. Seidman, "A Decision-Oriented Model of Urban Growth," paper presented to Fourth Annual Conference, Internat'l Fed. of Operations Research Societies (Boston, August 29 - September 2, 1966), and Seidman, "A Linear Interaction Model for Manufacturing Location," Delaware Valley Regional Planning Comm., Jan. 1964. (All above have been noted but not seen). See also: three pages in Ira S. Lowry, "Seven Models of Urban Development: A Structural Comparison"; RAND P-3673, Sept. 1967. r. Features Growth in an activity (e.g., residential location, manufacturing employment) determined in proportion to 1) average growth for whole region, 2) net migration determined by indices of attractiveness. Attractiveness determined by 1) current volume of activity, 2) effective area of district, 3) difference in desirability of subject and other districts, and 4) mobility of activity.		

MODEL		THE RAND TRANSPORTATION MODEL	
a. Purpose	Interaction of several location and rent patterns with transportation planning and development. Also: a general simulation of urban development.		
b. Principal developer	John Kain.		
c. Uses	1. Modeling research. 2. Submodels used in planning projects.		
d. When in development and use	First work on a submodel: late 1960. Have no information concerning this effort dated later than 1965.		
e. Costs	Not known, work begun on Ford Foundation grant to Rand, August, 1960.		
f. Where developed	Santa Monica and in several cooperating cities.		
g. Prototypes	None.		
h. Types of assumptions	Theoretical, descriptive.		
i. Number of players	None.		
j. Related and later developments	Efforts in process to update and implement with cooperation of National Bureau of Economic Research.		
k. Surrogate of what city	Total model never applied. Submodels applied to several cities but not known which.		
l. Type of model	Complex multistage computer simulation with at least five submodels and a separable transportation model of similar size. Time-oriented features in which model generates "status variables" for the next iteration.		
m. Computer, language and program	IBM 7094 at Rand, Fortran-type language, no information on listing.		
n. Number and types of parameters	Two sets of inputs of six major variables each. At least five "urban" submodels of four to six variables each. Six "transportation" submodels with two to five major variables each.		
o. Storage requirements	Not known.		
p. Data input requirements	Not specified, but immense. The six "status" variables alone encompass more data than is presently available in any city. Kain settles for data approximations. Number of data input items not known.		
q. Documentary sources	John F. Kain, "The Development of Urban Transportation Models," Regional Science Association Papers, Vol. 14, Ghent Congress 1964, pp. 147-173. Also, the following RAND documents: Kain and Meyer, RM-2878-FF; RM-2824-FF; Kain, RM-3086-FF; Kain, P-2549; Kain, P-2667; Niedercorn & Kain, P-2663.		
r. Features	Separate development of submodels of urban system: 1) workplace location, 2) housing location, 3) land use constraints, 4) employment distribution, 5) housing characteristics, 6) demographic characteristics. Six transportation submodels: 1) trip generation, 2) zone interaction, 3) mode choice, 4) route choice, 5) traffic characteristics, 6) systems modification. Many of these were never constructed in workable form. Urban model generates changes in characteristics and status variables, and provides inputs of rent surfaces and employment distributions for first transportation submodel. "Systems modification" submodel of transportation model, together with "status modification" submodel of urban system model, generate the succeeding iteration.		

MODEL		REGION	
To represent, in addition to land use development, economic interaction, governmental activity, inter-city competition, residential problems of social class.			
a. Purpose		1. Professional education. 2. Heuristic gaming for planning activities.	
b. Principal developer		Peter House. Also involved: Allan Feldt.	
d. When in development and use		1967 - 1968.	
e. Costs		Not known. Funded in house by Washington Center for Metropolitan Studies.	
f. Where developed		The Washington Center for Metropolitan Studies	
g. Prototypes		CLUG	
i. Number of players		24 - 40 (in eight teams)	
h. Types of assumptions		Theoretical.	
j. Related and later developments		CITY I.	
k. Surrogate of what city		None. City is hypothetical.	
l. Type of model		Computer assisted "systemic" (non-role-playing) game. Computer used for tabulation.	
m. Computer, language and program		IBM-1130, Fortran IV; no knowledge of program.	
n. Number and types of parameters		For each team: two dependent variables (cash remaining, and value of property assets); approx. 10-30 major independent variables (including transportation factors, depreciation, condemnation, taxes), depending on difficulty of the particular version used.	
o. Storage requirements		Not known.	
p. Data input requirements		Almost none, (except for that generated in the game).	
q. Documentary sources		Washington Center for Metropolitan Studies, Urban Systems Simulations, Manual for REGION; An Urban Development Model, (Washington, May 1968).	
r. Features		Eight teams compete to buy land, develop land, avoid deterioration, gain political power by developing residential projects. Teams elect mayor who controls utilities and the tax rate. Residence units elect zoning commissioner who may make zoning changes. Monte Carlo simulation of land auctioning and condemnation of deteriorated property. Six sectors: from basic industry to residential, all highly interconnected. Connection with national economy; division into endogenous and exogenous activity. Two competing cities with farm land, and competition to control municipal services. Division of residences into three social classes, with differing rules for each.	

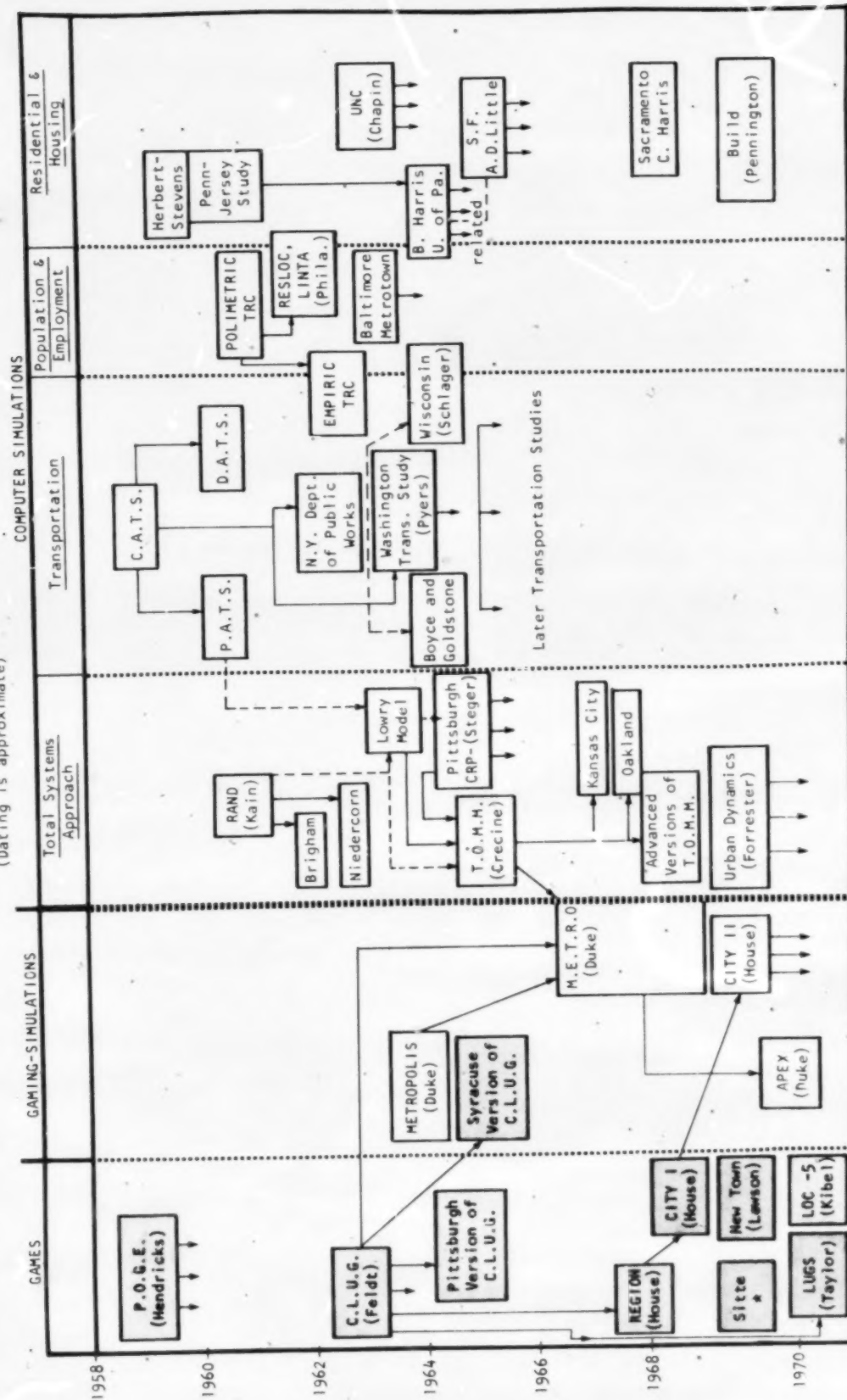
MODEL		SAN FRANCISCO COMMUNITY RENEWAL MODEL OR A.D. LITTLE MODEL	
a. Purpose	To simulate the construction, deterioration, and modification of housing structures in response to both governmental and market influences.		
b. Principal developer	Ira Robinson, Harry Wolfe.		
c. Uses	1. Modeling research. 2. Prediction and control for urban renewal programs.		
d. When in development and use	1964		
e. Costs	Not known.		
f. Where developed	San Francisco.		
g. Prototypes	None.		
h. Types of assumptions	Theoretical.		
i. Number of players	None.		
j. Related and later developments	Not known.		
k. Surrogate of what city	San Francisco.		
l. Type of model	Computer simulation.		
m. Computer, language and program	IBM 7090/7094, Fortran IV with certain subprograms in assembly language.		
n. Number and types of parameters	Not known.		
o. Storage requirements	Not known.		
p. Data input requirements	15,000 data items specified by 35,000 input numbers.		
q. Documentary sources	Arthur D. Little, Inc., Model of the San Francisco Housing Market, San Francisco Community Renewal Program, Technical Paper No. 8 (Jan. 1966) [noted but not seen]; Arthur D. Little, Inc., Community Renewal Programming: A San Francisco Case Study (New York: Praeger, 1966); Ira M. Robinson, Harry B. Wolfe, and Robert L. Barringer, "A Simulation Model for Renewal Programming," American Institute of Planners, Journal, Vol. 31, No. 2 (May 1965), pp. 126-134. Harry B. Wolfe and Martin L. Ernst, "Simulation Models and Urban Planning," in Operations		
r. Features	Matches 106 "neighborhoods," each containing about 500 "tracts" (about 2 acres) rated by 22 types of dwelling and four structural conditions, are matched to 106 types of households, identified by size, race, income, and rent-paying ability. Excess households or "tracts" determine new construction, demolition, or modification. Governmental plans are both input and output. "Accessibility" does not enter into calculation. 18-year projection is made in 9 two-year iterations.		
Research for Public Systems, Philip M. Morse (ed.), M.I.T. Press, 1967, pp. 49-81.			

MODEL		UNC MODEL (UNIVERSITY OF NORTH CAROLINA MODEL)	
a. Purpose	To represent land-use succession in the conversion of rural to residential land uses.		
b. Principal developer	F. Stuart Chapin, Jr.		
c. Uses	1. Modeling research. 2. Land-use research. 3. Planning and study tool.		
d. When in development and use	Developed 1961-1964. Later development at least to 1966. Some current operation.		
e. Costs	Takes approx. 116 seconds, and approx. 1 minute to set up program for a full 12-year projection. No knowledge of development costs.		
f. Where developed	University of North Carolina.		
g. Prototypes	None.		
h. Types of assumptions	Descriptive.		
i. Number of players	None.		
j. Related and later developments	Several different programs were written. Later work disaggregated model into three submodels: 1) household activity, 2) residential supply, 3) residential demand (see q below).		
k. Surrogate of what city	Greensboro, N. C.		
l. Type of model	Computer simulation with probabilistic submodel of allocation of sites.		
m. Computer, language and program	Univac 1105; Language: "Donnelly Program No. 1" -- IT and USE, "Donnelly Program No. 2" -- USE; Listings: Program 1 in A Probabilistic Model..., Program No. 2 in Some Input Refinements...		
n. Number and types of parameters	Four or five principal variables and set of four coefficients for priming factors for each development unit. No information concerning total unknowns.		
o. Storage requirements	Program 1: 8,000 words, core memory. Program 2: 12,020 words, core memory, with two data maps of size 72 x 72, and 5,184 words each.		
p. Data input requirements	q. Documentary sources Well documented in three research monographs: 1) F.S. Chapin, Jr., (Chapel Hill, August 1962). 2) Thomas G. Donnelly, F.S. Chapin, Jr., and Shirley Weiss, A Probabilistic Model for Residential Growth (Chapel Hill, May 1964). 3) F.S. Chapin, Jr. & Shirley Weiss, Some Input Refinement for a Residential Model (Chapel Hill, July 1965). (All monographs published by the Center for Urban and Regional Studies, Univ. of No. Carolina.) Also see: F. Stuart Chapin, Jr., "A Model for Simulating Residential Development," American Institute of Planners, Journal, Vol. 31, No. 2 (May, 1965) pp. 120-125. r. Features City divided into development units of about 20 acres, each divided into "ninths." At the beginning of each run, land in use or otherwise withdrawn from market is "sterilized." Remaining units are then given "attractiveness" ratings according to 1) current assessed value, 2) intervening development of adjacent business and residential activity, and 3) the effect of "priming factors," such as roads and utilities in the development plan. The priming factors were determined in an extensive multiple regression analysis. Households are considered uniform except for a disaggregation into three levels of density (households per ninth). Program allocates households to sites according to a probability distribution, weighted by density controls. Model used to project residential growth in 1960 in four three-year recursions, based on 1948 data.		

MODEL		URBAN DYNAMICS	
a. Purpose		To model the life cycle of a city from its founding and development through its growth and eventual stagnation. A second model begins with the city in a depressed condition and is used to determine, in a quantitative manner, how various policies would alter the condition of the urban area over the next 50 years.	
b. Principal developer		Jay W. Forrester.	
c. When in development and use		In development, 1968 - 1969. In use at present.	
d. Where developed		Massachusetts Institute of Technology.	
e. Types of assumptions		Theoretical and statistical.	
f. Related and later developments			
g. Surrogate of what city		None. Attempts to model general class rather than specifics.	
h. Type of model		Theoretical all-computer simulation with extremely high time compression.	
i. Computer, language and program		Not known. DYNAMO, II compiler utilized.	
j. Number and types of parameters		Not known.	
k. Storage requirements		Not known. However, type of model utilized has high storage requirements.	
l. Data input requirements		Initial values for all level variables in the system. The nine principal variables are: New Enterprise (NE), Mature Business (MB), Premium Housing (PH), Worker Housing (WH), Underemployed Housing (UH), Managerial-Professional (MP), Labor (L), and Underemployed (U).	
m. Documentary sources		Jay W. Forrester, <u>Urban Dynamics</u> , (Cambridge: MIT Press), 1969; John F. Kain, "A Computer Version of How A City Works," <u>Fortune</u> , November 1962, pp. 241-242; William K. Stevens, "Computer Scans Urban Ills and Overrules Experts," <u>New York Times</u> , Oct. 31, 1969, pp. 34-36.	
n. Features		Analysis of the processes necessary to the creation of and the correction of urban decay. Analyzes affect of various programs--training, financial aid, low cost housing, and urban renewal--on the above processes.	

A GENEALOGY OF URBAN SIMULATION MODELS

(Dating is approximate)



Western Behavioral Sciences Institute

KEY: Influences → Related to --- Continuing Use/Development → Manual Computer